



Retrospective Cohort Study: Predictors of Viral Load Suppression Time Among People Living with HIV

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Abstract

Acquired Immunodeficiency Syndrome (AIDS) represents the advanced stage of HIV infection and remains a major global public health challenge. Viral load testing is the main predictor of disease progression and a key indicator of antiretroviral (ARV) therapy success. In South Sumatra Province, viral load testing coverage in 2024 reached only 49%, below the national target of 75% and the global target of 95%, hindering progress toward the Ending AIDS 2030 goal. This study aimed to estimate the time to viral load suppression and identify its predictors among people living with HIV (PLHIV), complementing previous studies in areas with lower HIV prevalence. Using a retrospective cohort design and secondary data from the HIV AIDS and STI Information System Application version 2.1 (SIHA 2.1), the study analyzed 1,002 respondents through descriptive statistics and Cox regression survival analysis (Stata 15). Among the participants, 85.63% achieved viral load suppression, while 14.37% did not. Factors significantly associated with viral load suppression time included age ($p = 0.016$; HR 1.18; 95% CI 1.03–1.35), occupational status ($p < 0.001$; HR 1.63; 95% CI 1.34–1.99), ARV adherence ($p = 0.007$; HR 1.22; 95% CI 1.05–1.42), tuberculosis (TB) co-infection ($p = 0.003$; HR 1.31; 95% CI 1.09–1.57), and loss to follow-up history ($p = 0.003$; HR 1.41; 95% CI 1.12–1.75), after adjustment for sex and clinical stage. These findings underscore that age, employment, treatment adherence, TB co-infection, and LTFU history are key determinants of viral load suppression, emphasizing the need to strengthen treatment adherence programs to achieve the 95-95-95 targets and End AIDS 2030.

Introduction

HIV/AIDS has become a global public health problem. Human Immunodeficiency Virus (HIV) is an infection that attacks the human immune system, while Acquired Immunodeficiency Syndrome (AIDS) represents the advanced stage of HIV infection characterized by a collection of signs and symptoms of disease. The number of HIV/AIDS cases continues to increase, particularly among key high-risk populations such as female sex workers, transgender individuals, men who have sex with men (MSM), and people who inject drugs (Moyo et al., 2023; Baral et al., 2014; Decker et al., 2022; Needle et al., 2012; Poteat et al., 2015; Jin et al., 2021; Shannon et al., 2018). The World Health Organization (WHO) reported that in 2023, there were 39.9 million people living with HIV worldwide, of whom 38.6 million were adults (>15 years). Although 86% of people living with HIV (PLHIV) globally were aware of their HIV status (approaching the global target of 95%), only 77% had access to antiretroviral therapy (ART) (global target 95%), and merely 72% of those diagnosed and receiving

treatment achieved viral suppression (McMahon et al., 2013; Nachega et al., 2018; Yehia et al., 2012; Petersen et al., 2017).

In Indonesia, HIV/AIDS has progressed from a low-level epidemic to a concentrated epidemic (Wahyuniar, 2021; Fauk & Mwanri, 2015; Belawati et al., 2015). Data show that the highest proportion of HIV cases occurs among individuals of productive age, namely 25–49 years (71.6%) and 20–24 years (14.1%). In South Sumatra Province, a cumulative total of 5,339 PLHIV/AIDS cases were recorded from 1995 to December 2024. In 2024 alone, 992 new HIV/AIDS cases were identified. As of December 2024, 2,892 PLHIV were undergoing ART, yet only 2,039 (70%) of them had undergone viral load testing, and among these, only 66% achieved viral suppression.

HIV viral load testing serves as a superior predictor for monitoring the progression of HIV infection compared to CD4 cell counts, as it directly measures the quantity of HIV Ribonucleic Acid (RNA) in the blood, reflecting the level of viral replication (Korenromp et al., 2009; Drain et al., 2019; Belmonti et al., 2021; Nwanochie, 2024). Viral load testing is recommended for patients after the first six months of treatment, again at 12 months, and subsequently at least once annually, or earlier in cases of suspected treatment failure. Achieving viral load suppression plays a vital role in preventing HIV transmission to others and reducing the risk of opportunistic infections (World Health Organization, 2023; Erjino et al., 2023; Mukuku et al., 2025)s.

Viral load suppression, defined as a test result of ≤ 1000 copies/mL, is strongly influenced by consistent adherence to ART. Regular ART administration can reduce viral load by up to 77%, leading to improved clinical status and reduced transmission. However, achieving viral suppression remains a challenge in treatment success, as some PLHIV fail to undergo viral load testing, and not all who are tested achieve suppression. Therefore, this study is crucial to understand the predictors of viral load suppression among people living with HIV in South Sumatra Province.

Methods

Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Public Health, Sriwijaya University (No. 625/UN9.FKM/TU.KKE/2025, dated April 25, 2025). This study employed an observational analytic design with a retrospective cohort approach, focusing on identifying risk factors and effects of past conditions. Secondary data were utilized from viral load testing reports of PLHIV recorded and reported in the HIV AIDS and STI Information System (SIHA 2.1). Data were analyzed both descriptively and inferentially using Stata version 15. The study population comprised all PLHIV undergoing ART in South Sumatra Province who met the eligibility criteria for viral load testing in SIHA 2.1, totaling 2,039 individuals.

Sample selection was based on PLHIV who initiated ART between 2022 and 2024, were still undergoing ART, and had undergone viral load testing, resulting in 1,040 individuals. After checking data completeness, a final total of 1,002 cases were included in the analysis. Descriptive analysis was conducted to describe the characteristics of each variable, while inferential analysis employed bivariate Cox regression to examine predictors influencing viral load suppression time among PLHIV. Follow-up began from the initiation of ART until viral load testing was conducted. PLHIV were considered censored if viral suppression was not achieved, were lost during observation, or died during the study period. PLHIV who achieved viral suppression during the follow-up were categorized as events. After simple Cox regression, survival analysis was further performed using the Kaplan–Meier method.

The dependent variable in this study was HIV viral load status, categorized as suppressed (≤ 1000 copies/mL) or not suppressed (> 1000 copies/mL). Independent variables included sex,

age, occupational status, clinical stage, treatment adherence, history of tuberculosis (TB) infection, and history of loss to follow-up (LTFU).

Result and Discussion

Data analysis showed that 52.2% of PLHIV who underwent viral load testing were under 30 years of age, and 82.83% were male. Based on occupational status, the majority of PLHIV were employed (87.3%). Regarding clinical stage at the initiation of ART, 59.38% started treatment at an early stage (Stage I and II), while 40.02% were at an advanced stage (Stage III and IV). In terms of ART adherence, most participants demonstrated high adherence (59.38%), with the longest treatment duration being more than 12 months (49.3%). Viral load testing results indicated that the majority of PLHIV (85.63%) achieved viral suppression (Table 1).

Table 1. Distribution of PLHIV Characteristics

Variable	Frequency (n)	Percentage (%)
Age		
1. >30 Years	479	47,80
2. ≤30 Years	523	52,20
Gender		
Female	172	17,17
Male	830	82,83
Occupational status		
employed	874	87,3
unemployed	128	12,77
Clinical Stage		
Early stage	601	59,98
Advanced stage	401	40,02
Adherence		
High	595	59,38
Low	407	40,62
History of LTFU		
Never	885	88,32
Ever	117	11,68
History of TB infection		
Never	793	79,14
Ever	209	20,86
Treatment duration		
>12 months	494	49,3
6-12 months	431	43,01
<6 months	77	7,68
Viral load outcome		
Not suppressed	144	14,37
Suppressed	858	85,63

The proportion of viral load suppression events was 59.9% (95% CI: 56.9–62.9) with a total observation period of 14,355 person-months for 1,002 patients, resulting in an incidence rate of 59.8 per 1,000 person-months. Kaplan–Meier curves demonstrated the overall time to viral load suppression, with a median survival time of approximately 13 months, indicating that 50% of PLHIV achieved viral suppression about 13 months after initiating ART (Figure 1). The mean time to viral suppression was 10 months.

Table 2 shows that age ($p = 0.002$), occupational status ($p < 0.001$), clinical stage ($p = 0.047$), treatment adherence ($p < 0.001$), history of TB infection ($p < 0.001$), and history of LTFU (p

< 0.001) were significantly associated with viral load suppression. However, sex was not significantly associated with viral load suppression.

Multivariate analysis revealed that five variables were significantly associated with viral load suppression among PLHIV receiving ART: age ($p = 0.016$; adjusted HR 1.18, 95% CI: 1.03–1.35), occupational status ($p < 0.001$; adjusted HR 1.63, 95% CI: 1.34–1.99), ART adherence ($p = 0.007$; adjusted HR 1.22, 95% CI: 1.05–1.42), history of TB infection ($p = 0.003$; adjusted HR 1.31, 95% CI: 1.09–1.57), and history of LTFU ($p = 0.003$; adjusted HR 1.41, 95% CI: 1.12–1.75).

Table 2. Bivariate Analysis of Predictors Associated with Viral Load Suppression

Variable	Viral Load				Incidence Rate (Per 1000)	p-value	HR (95%CI)
	Not Suppressed		Suppressed				
	n	%	n	%			
Gender							
Female	30	17,44	142	82,56	59	0,340	1,09 (0,91-1,31)
Male	114	13,73	716	86,27	62		
Age							
>30 Years	76	52,78	403	46,97	56	0,002	1,24 (1,08-1,41)
≤30 Years	68	47,22	455	53,03	64		
Occupational status							
Employed	132	91,67	742	86,48	57	<0,001	1,67 (1,37-2,04)
Unemployed	12	8,33	116	13,52	86		
Clinical stage							
Early Stage	86	59,72	515	60,02	58	0,047	1,15 (1,00-1,32)
Advanced Stage	58	40,28	343	39,98	63		
ART adherence							
Low	59	59,03	348	59,44	64	<0,001	1,29 (1,12-1,48)
High	85	40,97	510	40,56	57		
TB history							
Ever	34	23,61	175	20,40	72	<0,001	1,42 (1,20-1,68)
Never	110	76,39	683	79,60	57		
LFU History							
Ever	31	21,53	86	10,02	44	<0,001	1,52 (1,21-1,90)
Never	113	78,47	772	89,98	62		

Table 3. Final Multivariate Cox Regression Analysis

Variable	P value	Hazard Ratio (HR)	95% CI	
Age	0,016	1,18	1,03	1,35
Occupational status	<0,001	1,63	1,34	1,99
ART adherence	0,007	1,22	1,05	1,42
TB infection	0,003	1,31	1,09	1,57
LFU History	0,003	1,41	1,12	1,75

This study aimed to assess the time to viral load suppression and its predictors. In this study, the incidence rate of viral load suppression was 5.98 per 100 person-months, which is lower than that reported in similar studies in Ethiopia. A study conducted in Gebi Resu Zone, Afar Region, Ethiopia, reported an incidence rate of 9.46 per 100 person-months with a median suppression time of 7.7 months (Workie, Mohammed, & Abebe, 2024). Another study in Southern Ethiopia reported an incidence rate of 9.68 per 100 person-months (95% CI: 8.56–10.94) (Tadele, Taye, & Mekonnen, 2023). These differences may be attributed to variations in patient characteristics, the quality of HIV treatment services, treatment adherence, and differences in viral load monitoring systems across regions. These findings highlight the importance of further analysis of viral load suppression incidence, as it is essential for evaluating treatment effectiveness and identifying predictors of time to viral load suppression. On average, PLHIV required approximately 10 months to achieve viral load suppression. This is consistent with a study in Ethiopia that compared ART regimens, which found an average suppression time of 10.43–10.65 months, depending on the viral load threshold (<200 or <50 copies/mL) (Ayal & Berha, 2023).

The results of the multivariate Cox regression analysis revealed five variables age, employment status, ARV treatment adherence, history of TB infection, and history of loss to follow-up (LFU) that were associated with the predictors of time to viral load suppression. These findings are consistent with the literature, which emphasizes that individual, socioeconomic, adherence-related, and comorbidity factors strongly influence the rate of viral load suppression (Sari et al., 2025; Chirnet et al., 2024). PLHIV in older age groups demonstrated a higher likelihood of achieving viral load suppression compared to younger individuals. This finding is in line with cohort studies in Ethiopia showing that older age groups tend to achieve faster suppression, largely due to better treatment adherence and greater socioeconomic stability (Ali et al., 2019). Employment status was also shown to be significantly associated with viral load suppression, with PLHIV in stable employment achieving faster suppression. This result is supported by international studies demonstrating that financial independence facilitates better adherence and access to HIV treatment services (Pyngottu et al., 2021). Furthermore, employed PLHIV tend to perceive themselves as more active and productive, which increases their productivity and reduces self-stigma or negative perceptions related to their HIV status and treatment burden (Safitri, 2020).

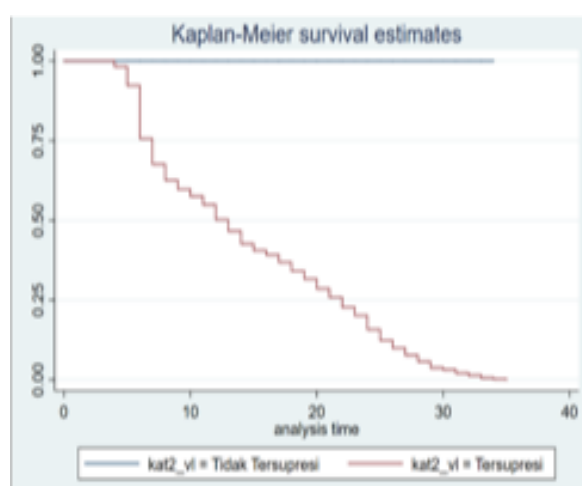


Figure 1. Overall Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV

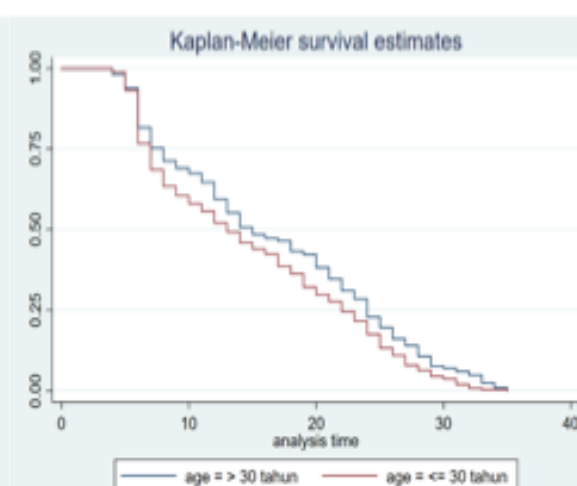


Figure 2. Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV by Age

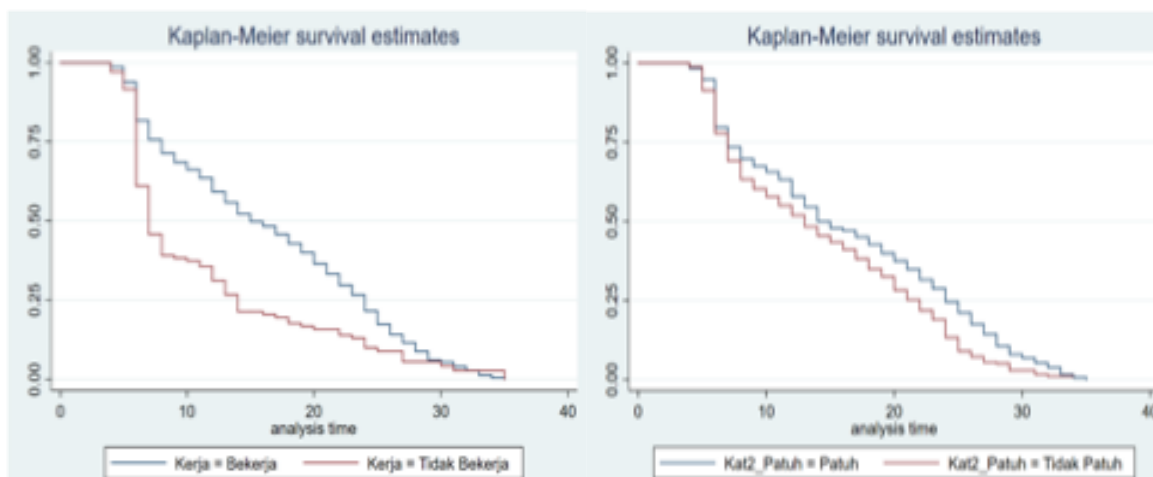


Figure 3. Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV by Employment Status

Figure 4. Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV by Treatment Adherence

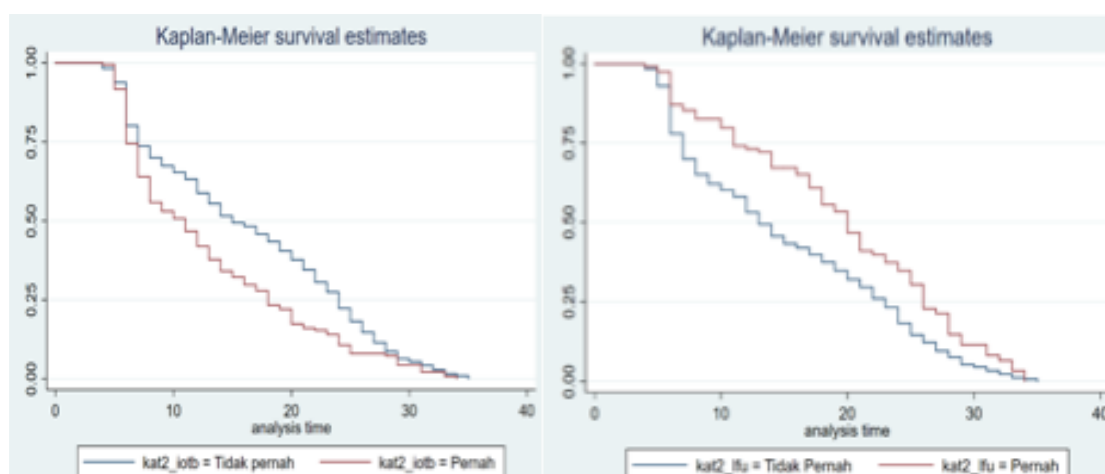


Figure 5. Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV by History of TB Infection

Figure 6. Kaplan-Meier Curve of Time to Viral Load Suppression among PLHIV by History of LFU

Treatment adherence was shown to increase the likelihood of viral load suppression by 22%. This finding is consistent with Ethiopian studies on time to suppression, which demonstrated that patients with higher adherence levels achieved viral load suppression more rapidly compared to those with poor adherence (Chirnet et al., 2024; Atnafu et al., 2022). Patients who consistently took $\geq 95\%$ of their prescribed doses experienced faster reductions in viral load, as drug concentrations in the body remained above the effective threshold required to inhibit HIV replication (Qin et al., 2021). Enhancing adherence counseling has also been shown to improve viral load suppression, particularly in patients with initially high viral load levels (Belete et al., 2024). Counseling and education are routinely provided during monthly ARV refill visits. Additional strategies, including medication reminders, peer support, and flexible clinic schedules, should be strengthened to further improve adherence to HIV treatment.

A history of TB infection was also associated with an increased likelihood of viral load suppression. This may be due to strengthened services provided to TB-HIV patients, including tuberculosis preventive therapy (TPT) and more frequent counseling sessions, as reported by

Erjino et al. (2023). Research by Rizka et al. (2024) further explained that while HIV patients with TB co-infection face greater clinical challenges, those who successfully complete TB treatment and continue ART tend to demonstrate better immunological responses and higher adherence to therapy. History of LFU was also significantly associated with viral load suppression. Irregular ARV use due to LFU can lower plasma drug concentrations, increase the risk of treatment failure, and delay viral load suppression. The literature indicates that LFU generally has negative effects, except in cases where patients returning to care receive more intensive interventions (Bankere et al., 2024).

Conclusion

The median and mean time to viral load suppression were longer compared to findings from studies conducted in other developing and developed countries. The study results indicate that age, employment status, ARV treatment adherence, history of TB infection, and history of LFU are associated with predictors of the time to viral load suppression. Enhancing treatment adherence, strengthening socioeconomic support, integrating TB-HIV services, and implementing strategies to maintain treatment among PLHIV such as case tracing, peer group support, and the provision of Multi-Month Dispensing (MMD) are essential to accelerate the achievement of viral load suppression targets and to support the success of HIV control programs in South Sumatra.

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